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From the Editors

The substantive papers in this issue of *The Victorian Naturalist* might be seen as falling into two different categories – on the one hand dealing with natural history, and on the other with photographic history.

It is interesting to note that, in the digital age, photographic history is aligned in the pursuit of natural history, with camera traps used more and more to discover and record species, both native and feral, in a non-intrusive manner. Camera traps have become a valuable addition to the techniques used in fauna survey and a regular part of field work.

Thus the studies reported by Sinclair and Gibson on bryophyte reproduction, and by Grey and Grey on a rare coral fungus, took place in the species' natural environment, whereas Woodford's paper, on the first use of camera traps, while essentially historical, discusses techniques that have become a regular part of field work.

These papers also provide good examples of some of the keys to success in studies of natural history: well-defined questions, a workable field strategy, good fortune and innovation.

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Front cover: Common Brushtail Possum *Trichosurus vulpecula* caught on camera. Photo by Anne Morton.
Back cover: A praying mantis advancing on a butterfly. Photo by Anne Morton.

Sex expression and reproduction of four bryophytes following timber harvesting

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Abstract

Many factors are reported to affect reproduction in bryophytes but studies on the response of sexual reproduction to logging are extremely rare and the authors know of none for Australia. This paper reports the seasonal changes in sex expression and phenological development across a post-logging chronosequence for four species. Three species, *Rhaphidorrhynchium amoenum, Rhynchostegium tenuifolium* and *Wijkia extenuata*, were pleurocarpous and one, *Rosulabryum billarderii*, was an acrocarpous species. Reproduction in pleurocarpous species is seldom investigated because of the difficulty of untangling individual stems. Sex expression in terms of the numbers of male and female stems, number of perichaetia and perigonia, number of archegonia, antheridia and sporophytes did not differ across the chronosequence, so it would appear that forest age did not affect reproductive phenology. (*The Victorian Naturalist*, 132 (6), 2015, 160-169)

Keywords: bryophytes, phenology, reproduction, logging, chronosequence

Introduction

It is essential that bryophytes have the ability to reproduce sexually for harvested forests to return to pre-harvest levels of bryophyte composition and richness with a high degree of genetic diversity amongst populations. Many bryophytes reproduce only by asexual means (Longton 1976), implying they may be unable to cope with changing environments (Stark *et al.* 1998); however, as long as periods of sexuality occur, there is no reason why bryophytes could not benefit from both long- and short-term advantages provided by both forms of reproduction (Longton 1976). Asexual reproduction is considered important for colony expansion and maintenance (Longton 1976, 2006), while sexual reproduction is considered important for genetic diversity, providing for the potential of survival in changed conditions and development of new populations in a new ecology (Longton 2006).

Many factors affect reproduction in bryophytes. For example, stress caused by changes in the physicochemical nature of the environment is known to promote a female-biased sex ratio (Stark 2002). Bryophytes depend on the appropriate signals for sex expression, and developmental pattern of gametangia and sporophytes. If the appropriate signals are lacking, the phenological events may not occur. Inhibition of archegonial maturation, when sperm are ready for release, would prevent fertilisation events (Longton 1972). If conditions have changed, growth can be affected. This, in turn, can affect reproduction. Benassi *et al.* (2011) concluded that limited water availability could stunt plants and thus inhibit sex expression, promote growth of female-only individuals and, therefore, limit sexual reproduction. Their data suggested that males of *Syntrichia caninervis* required more consistent water availability as they had a lower tolerance for repeated cycles of wetting and drying. Younger forests would have very different wetting and drying cycles from those in older forests, which, therefore, could affect reproduction. Needless to say, other factors that could be important to reproduction also vary between younger and older forests. Photoperiod would be shorter in a more closed forest than open forest because of shading effects. Similarly, temperatures are more extreme in open than closed forests. Nutrient levels also vary with forest age and may affect reproduction. The high nutrient demand necessary for reproduction means that limited nutrient levels can inhibit reproduction. In *Syntrichia caninervis*, Bowker *et al.* (2000) found greater sex expression was associated with shady microhabitats, higher soil moisture, greater nutrient availability and taller ramets. Male ramets were restricted to shaded microhabitats whilst female ramets were found in both shaded and exposed microhabitats. Forests at various stages

of regeneration post-logging vary markedly in moisture levels, light and temperature regimes and nutrient availability, thus cues for sexual reproduction may vary with time or, in fact, be absent. It is important, thus, to understand logging effects on bryophyte reproduction.

Such studies are extremely few and, currently, effects of logging on bryophyte reproduction can be inferred only from studies where another disturbance has been investigated; however, Cronberg *et al.* (2003) investigated the sex ratio in the moss *Plagiomnium affine* in forests of contrasting age after timber harvest, screening for genetic variation at 23 allozyme loci. They found female bias occurred at the ramet level but balanced sex ratios occurred at the genet level. Forest age was positively correlated with sporophyte numbers and negatively correlated to the percentage of non-expressed shoots.

The number of studies on sex ratios outside the logging scenario is considerable. Such studies involve investigation into the number of stems bearing perichaetia or perigonia and whether sexual reproduction is taking place, usually evidenced by the presence and number of sporophytes. The number of non-expressed stems also is taken into account. Given that 60% of bryophytes worldwide are dioicous (Wyatt and Anderson 1984), most studies on sex ratios have been undertaken on dioicous species, whilst monoicous species have been neglected. Dioicous species are known for having a female biased sex ratio and high levels of non-expressed stems, with many studies on individual species showing this (Shaw and Gaughan 1993; Stark *et al.* 1998; Benassi *et al.* 2011; Cronberg *et al.* 2003; Stark *et al.* 2010; Rydgren *et al.* 2010). Bisang and Hedenäs (2005) reviewed the sex ratios of 89 dioicous moss and liverwort species using literature reports and their own investigations, as well as herbarium specimens, of which ten were from Australia. They found 88% of herbarium specimens or 'patch in the field' and 68% of 'shoots in the field' showed a female skewed ratio. This 'trait' of dioicous species is strange, given that sex chromosome formation through meiosis 'should' result in the formation of male and female spores in equal numbers (Shaw and Gaughan 1993; Bisang and Hedenäs 2005). A number of possible explanations have been put forward to explain this phenomenon. Stark (2002) suggested that female skewed sex ratios may be a product of a higher realised cost of sexual reproduction in males; however, Bisang *et al.* (2006) found *Pseudocalliergon trifarium* showed no detectable costs to explain male rarity when they investigated the cost of allocation to sexual branches.

Monoicous bryophytes develop both male and female gametangia on the one stem and have been found to be self-fertilising in the mosses *Phascum cuspidatum, Pottia truncata* and *Weissia controversa* (Roads and Longton 2003). Cross fertilisation takes place in other monoicous species such as *Atrichum undulatum, Tortula muralis* (Longton and Miles 1982) and *Entodon cladorrhizans* (Stark 1983). The ability to self-fertilise produces a higher number of sporophytes in monoicous as opposed to dioicous species.

This study investigated the sex expression of four bryophyte species inhabiting forests regenerating after clearfell-burn-sow logging over a chronosequence in Wet Sclerophyll Forest (WSF) in the state of Victoria, Australia. The specific aims were to determine: (1) if sexual reproduction occurred; (2) the timing of phenophases and whether these were affected by years-since-harvest; (3) whether a bias in sex expression occurred; and (4) if sex expression altered with years-since-harvest.

Methods

Study Area

Toolangi State Forest is located in the Central Highlands of Victoria approximately 80 km north-east of Melbourne (Fig. 1). The climate is described as temperate with a mean annual temperature of 15.8°C and monthly means ranging from 8.6°C to 23.2°C. The mean annual rainfall is 1370 mm. Mean monthly rainfall varies from 77 mm to 138.5 mm (Bureau of Meteorology 2008).

The area has wet sclerophyll forest dominated by *Eucalyptus regnans*, which is able to reach heights of 100 m (Attiwill and May 2001; Costermans 1996) although records prior to 1935 included specimens higher than 100 m (Ashton 1975; 2000; Beadle 1981; Hardy 1968; DNRE 1996). *Eucalyptus regnans* is the tallest (Beadle 1981) and fastest growing eucalypt (Ashton and Attiwill 1994), thus such ecosystems are used

Fig. 1. Location of the Central Highlands (green) in Victoria, Australia.

widely for forest harvesting. Selective logging was undertaken in Toolangi State Forest prior to severe bushfires in 1926 and 1939, and salvage operations were conducted following these fires (Ough and Ross 1992; DNRE 1996). Since the 1960s, clearfell logging has been the major silvicultural technique used in the area.

Sampling

Forests of five age classes along a chronosequence were selected for investigation, all previously having undergone clearfell logging. Applicable sites were derived from logging history maps supplied by the then Department of Natural Resources and Environment. Sites consisted of areas logged 10, 15, 20, 25 and 30 years prior to the study. All had been burnt previously in the 1939 wildfire. These ages were chosen because the target species occurred frequently, allowing for the sampling regime. When these species were present within younger sites, they occurred less frequently, more sporadically, and in much smaller populations. Also investigated was a 63-year-old forest regenerating from the 1939 wildfire that had not been logged or burnt since.

A 900 m^2 quadrat was examined within each of five sites from each age class. Sites were determined using a computer-generated random number table. Quadrat size and number was determined by the use of a 'species area curve' (Andrew and Mapstone 1987) undertaken in the 63-year-old forest, which was visually most species-rich.

To limit any possible edge effects, quadrat placement was at least 50 m from any road edge or forest of a different age or type. Sampling occurred from October 2002 to November 2003.

Four bryophyte species common to wet sclerophyll forests were chosen for investigation: *Wijkia extenuata* (Fig. 2a), *Rhaphidorrhynchium amoenum* (Fig. 2b), *Rosulabryum billarderii* (Fig. 2c) and *Rhynchostegium tenuifolium* (Fig. 2d). *Rhaphidorrhynchium amoenum* is a monoicous species widespread throughout Australia and New Zealand (Scott and Stone 1976). It is found in all but the driest of habitats (Meagher and Fuhrer 2003) on trunks of trees, rocks, soil and logs. It grows in densely woven mats and is pinnately branched. *Rhynchostegium tenuifolium* is a soft, slender, pleurocarpous moss quite variable in its appearance, either matted into flattened tufts or loose and straggly. It is an autoicous species, which means the perichaetia and perigonia occur on the same plant, but never on the same stem or branch. It is found widely throughout southern Australia (Meagher and Fuhrer 2003), and commonly inhabits soil, logs and bark in wet habitats. *Rosulabryum billarderii* is an acrocarpous, dioicous species widely spread throughout all of Australia. It occurs also in Asia, South and Central America, Africa, New Zealand, Oceania and Europe (Scott and Stone 1976). It is found in many habitats but is known to occur mostly in wet environments. *Wijkia extenuata* is also a dioicous species common to wet habitats throughout Victoria, Tasmania, ACT and NSW (Scott and Stone 1976). It also occurs in New Zealand. It is a pleurocarpous, prostrate, matted moss, commonly found on logs, soil, trunks, rocks and ferns.

Within each forest of differing age, 50 stems of each species were collected seasonally over a 12 month period. Each stem was examined for the presence of perichaetia, perigonia and sporophytes, the number of each was recorded and sex expression of stems determined. They were further examined for the number of antheridia and archegonia. These, along with the sporophytes, were assigned a maturation stage (Longton and Green 1969) (Table 1).

Data Analysis

Analysis of similarity (ANOSIM) was conducted to determine if a difference in the num-

Table 1. Maturation stages of mosses (derived from Longton and Greene 1969)

Stage	Description
Sporophytes	
Swollen venter (SV)	Venter of archegonium begins to swell
Early calyptra in perichaetium (ECP)	Calyptra assumes pale yellnw colour
Late calyptra in perichaetium (LCP)	Calyptra becomes half exserted from perichaetial bracts
Early calyptra intact (ECI)	Calyptra becomes fully exserted from perichaetial bracts
Late calyptra intact (LCI)	Swelling of capsule begins
Early operculum intact (EOI)	Operculum becomes brown in colour
Late operculum intact (LOI)	Capsule becomes brown in colour
Operculum fallen (OF)	Operculum falls
Empty and fresh (EF)	75% of spores are shed
Aborted (A)	Apex of sporophyte wither prior to spore formation, usually in ECP, LCP or ECI stages
Gametangia	
Juvenile (J)	Gametangia become visible. Pale green colour
Immature (I)	Gametangia reach half length of dehisced gametangia
Mature (M)	Apices nf gametangia rupture. Archegonia become receptive for fertilisation and liberation of antherozoids begins.
Dehisced(D)	Development of brown colouration begins in gametangia at ruptured apices
Aborted (A)	Development of brown or hyaline colouration begins in gametangia with unruptured apices in J or I stages

Fig. 2. a) *Wijkia extenuata*; b) *Rhaphidorrhynchium amoenum*; c) *Rosulabryum billarderii*; and d) *Rhynchostegium tenuifolium*. Photos by Bernadette Sinclair.

ber of perichaetia, perigonia, sporophytes and gametangia existed for each species across the chronosequence. ANOSIM provides a test statistic, R, between -1 and 1. If R=0, there is no difference in the reproductive traits along the chronosequence. If R=1 or -1, perfect separation exists.

Results

Sex expression

Sex expression of stems within each forest age-class was higher than non-expression for the three pleurocarpous species (Table 2). The two dioicous species, *Rosulabryum billarderii* (acrocarpous) and *W. extenuata*, produced more female than male stems (Table 2b, d). The female bias was very strong in *Rosulabryum billarderii*, as few male stems occurred; however, the total number of sexually non-expressing stems was high for this species. At times the number of perigonia or antheridia occurring within an age class reduced the female bias, especially in *W. extenuata*. In *W. extenuata*, there was a trend for variation in sex expression of stems to be greater in forests at either end of the temporal chronosequence. In no instance did statistically significant variation of reproductive attributes occur across the temporal chronosequence for either species (*Rosulabryum billarderii*: Fertile and non-fertile stems: Global R=0.03; p=0.63. Perichaetia and perigonia: Global R=0.08; p=0.81. Archegonia and antheridia: Global R=0.53; p=0.06. *W. extenuata*: Fertile and non-fertile stems: Global R=0.06; p=0.70. Perichaetia and perigonia: Global R=0.01; p=0.56. Archegonia and antheridia: Global R=0.13; p=0.94).

Rhapidorrhynchium amoenum is recognised as a monoicous species (Scott and Stone 1976) and although the majority of stems expressed monoicy, a number of stems were found to bear solely female or solely male organs (Table 2a). The female bias was clearly shown in terms of higher numbers of perichaetia although greater numbers of antheridia than archegonia occurred within four age classes. Forest age did not show an affect on any of these reproductive attributes (Fertile and non-fertile stems: Global R=0.17; p=0.03. Perichaetia and perigonia: Global R=0.11; p=0.92. Archegonia and antheridia: Global R=0.43; p=0.99). Pairwise tests showed a significant difference occurred between forests of 15 and 25 years-since-harvest (R=0.698; p=0.03) but this one-off occurrence was not considered indicative of an effect of forest age and is attributed to chance.

Rhynchostegium tenuifolium did not bear any female only or male only stems; all stems bore both sexes as expected for a monoicous species (Table 2c). Perigonia outnumbered perichaetia in forests of 15–30 years-since-harvest, as did antheridia compared to archegonia, thus a male bias occurred. Antheridia also outnumbered archegonia in forests of 10 years-since-harvest. Again, forest age did not show any effect on reproductive attributes (Fertile and non-fertile stems: Global R=0.10; p=0.86. Perichaetia and perigonia: Global R=0.13; p=0.04. Archegonia and antheridia: Global R=0.15; p=0.90).

Only *Rhaphidorrhynchium amoenum* showed a comparatively respectable number of sporophytes (795) from a total of 1200 stems (Table 2a). The other three species had 151 or fewer sporophytes out of 1000 stems (Table 2b-d). ANOSIM showed no significant differences across the temporal chronosequence for any of the four moss species (*Rhaphidorrhynchium amoenum*: Global R=0.13; p=0.95. *Rhyncostegium tenuifolium*: Global R=0.23; p=0.93. *W. extenuata*: Global R=0.18; p=0.99 *Rosulabryum billarderii*: Global R=0.25; p=0.19).

Phenology

Generally, the sequence and timing of sporophyte development for each species was similar for each forest age class so data was pooled for each species and peaks of each phenostage were used to better show the phenological development (Fig. 3). *Rhaphidorrhynchium amoenum* began sporophyte development in spring with the production of swollen venters, while *W. extenuata* began in summer. Both showed a similar sequence of development, and completed their cycles within 12 to14 months with empty and fresh sporangia peaking in summer (Fig. 3). The data for *Rhynchostegium tenuifolium* have gaps but are suggestive of a similar developmental sequence to those of *Rhaphidorrhynchium amoenum* and *W. extenuata* (Fig. 3). Data for *Rosulabryum billarderii* were insufficient to make any meaningful deductions as to the developmental sequence of sporophytes.

Table 2. Sex expression of a. *Rhaphidorrhynchium amoenum* b. *Rosulabryum billarderii* c. *Rhynchostegium tenuifolium* d. *Wijkia extenuata* in different aged forest post harvest (NE = Non expressed stems).

a. Rhaphidorrhynchium amoenum (pleurocarpous)

	Forest age							
Number of:	10	15	20	25	30	63	Total	Mean
Stems examined	200	200	200	200	200	200	1200	
% fertile stems	65.5	82.5	75.5	55.5	70.5	53.5		67.2
% NE stems	34.5	17.5	24.5	44.5	29.5	46.5		33
Female stems	0	6	12	5	0	0	23	
Male stems	0	9	6	5	0	0	20	
Male & female stems	131	150	133	101	141	107	763	
NE stems	69	35	49	89	59	93	394	
Perichaetia	304	223	236	205	243	274	1485	
Perigonia	166	197	229	187	264	150	1193	
Ratio perichaetia:perigonia	1.8:1	1.13:1	1.03:1	1.09:1	1:1.09	1.8:1		1.2:1
Archegonia	93	138	75	224	0	123	653	
Antheridia	285	91	338	72	190	215	1191	
Ratio archegonia:antheridia	1:3.1	1.5:1	1:4.5	3.1:1	0:1	1:1.8		1:1.8
Sporophytes	163	153	112	123	113	130	794	
Fertile stems with sporophytes	131	165	151	111	141	107	806	

b. *Rosulabryum billarderii* (acrocarpous)

	Forest age						
Number of:	10	15	20	30	63	Total	Mean
Stems examined	200	200	200	200	200	1000	
% fertile stems	23.5	15	35.5	28	31		26.6
% NE stems	76.5	85	64.5	72	69		73.4
Female stems	46	29	58	49	53	235	
Male stems	1	1	13	7	9	31	
NE stems	153	170	129	144	138	734	
Perichaetia	46	29	58	49	53	235	
Perigonia	1	1	13	14	9	38	
Ratio perichaetia:perigonia	46:1	29:1	4.5:1	3.5:1	5.9:1		6.2:1
Archegonia	25	168	0	54	45	292	
Antheridia	14	0	87	24	0	125	
Ratio archegonia:antheridia	1.8:1	168:0	0:9	2.3:1	45:0		2.3:1
Sporophytes	11	7	12	10	20	60	
Fertile stems with sporophytes	47	30	71	56	62	266	

c. *Rhynchostegium tenuifolium* (pleurocarpous)

	Forest age						
Number of:	10	15	20	25	30	Total	Mean
Stems examined	200	200	200	200	200	1000	
% fertile stems	48.5	37.5	46.5	35	41.5		41.8
% NE stems	51.5	62.5	53.5	65	58.5		58.3
Male & female stems	97	75	93	70	82	417	
NE stems	103	125	107	130	118	583	
Perichaetia	120	84	94	134	128	560	
Perigonia	103	127	104	188	95	617	
Ratio perichaetia:perigonia	1.2:1	1:1.5	1:1.1	1:1.4	1.4:1		1:1.0
Archegonia	186	84	102	78	88	538	
Antheridia	311	323	300	442	78	1454	
Ratio archegonia:antheridia	1:1.7	1:3.9	1:2.9	1:5.7	1:1.1		1:2.7
Sporophytes	12	5	17	23	33	90	
Fertile stems with sporophytes	97	75	93	70	82	417	

Table 2 cont.

d. *Wijkia extenuata* (pleurocarpous)

Number of:	Forest age 10	15	20	25	30	63	Total	Mean
Stems examined	200	200	200	200	200	200	1200	
% fertile stems	59.5	44.5	58.5	69	60	69.5		60.2
% NE stems	40.5	55.5	41.5	31	40	30.5		41.3
Female stems	71	38	62	70	61	83	385	
Male stems	30	51	55	68	59	56	319	
Ratio female:male stems	2.4:1	1:1.3	1.1:1	1.0:1	1.0:1	1.5:1		1.2:1
NE stems	99	111	83	62	80	61	496	
Perichaetia	129	77	146	118	106	169	745	
Perigonia	94	229	204	186	225	357	1295	
Ratio perichaetia:perigonia	1.37:1	1:2.97	1:1.4	1:1.58	1:2.12	1:2.11		1:1.7
Archegonia	141	142	142	124	99	170	818	
Antheridia	131	439	355	147	115	451	1638	
Ratio archegonia:antheridia	1.08:1	1:3.09	1:2.5	1:1.19	1:1.16	1:2.65		1:2.0
Sporophytes	30	26	24	17	21	33	151	
Fertile stems with sporophytes	119	89	117	138	120	139	722	

Age of forest did not seem to have affected the timing and sequence of development for archegonia and antheridia so, as was done for sporophytes, data were pooled for each species to better demonstrate any pattern in phenological development. All stages of development in *Rhaphidorrhynchium amoenum* occurred in spring although dehisced archegonia were also noted in summer and winter. The observation of mature archegonia receptive for fertilisation during spring supports the findings that the number of sporophytes at the swollen venter stage occurred during this season (Fig. 3). Juvenile and immature antheridia peaked in winter while mature and dehisced antheridia peaked in spring, suggesting antherozooids were available for fertilisation. The maturation of the archegonia and antheridia and the occurrence of swollen venters during spring provide strong evidence that fertilisation occurs during this season.

The number of juvenile archegonia of *W. extenuata* peaked in autumn, which was followed by a peak in number of immature archegonia in winter, then a peak in number of mature archegonia in winter and spring and, lastly, a peak in number of dehisced archegonia in summer. The data for antheridia did not allow interpretation of a phenological sequence.

The juvenile, immature and mature phenostages of both archegonia and antheridia of *Rhynchostegium tenuifolium* peaked in summer but dehisced stages peaked in autumn. The accompanying peak in swollen venters in summer (Fig. 3) strongly suggests fertilisation occurred during this season.

With respect to *Rosulabryum billarderii*, all phenostages of archegonia peaked in spring although juvenile and mature stages occurred in good numbers in winter, but only in forests of 15 years-since-harvest. Antheridia were noted only in spring but all were at the immature stage.

Discussion

Each of the four species produced sporophytes at the swollen venter stage when gametangia were mature and gametes were available for fertilisation events. Thus the evidence is very strong that sexual reproduction occurs in each of the four species examined and does so regularly, although the data for both *W. extenuata* and *Rosulabryum billarderii* were insufficient to determine the phenological development of antheridia.

Although the data sets were incomplete, as not all stages were found in all forest age groups, forest age did not appear to inhibit sexual reproduction or its timing. As logging was shown to reduce species richness significantly (Sinclair 2012), these findings are reassuring in that they suggest logging does not affect the sexual abilities and capacities of those species able to recolonise, and they should be able to survive in the regenerating forests. These four species, however, are common, and the story for less common

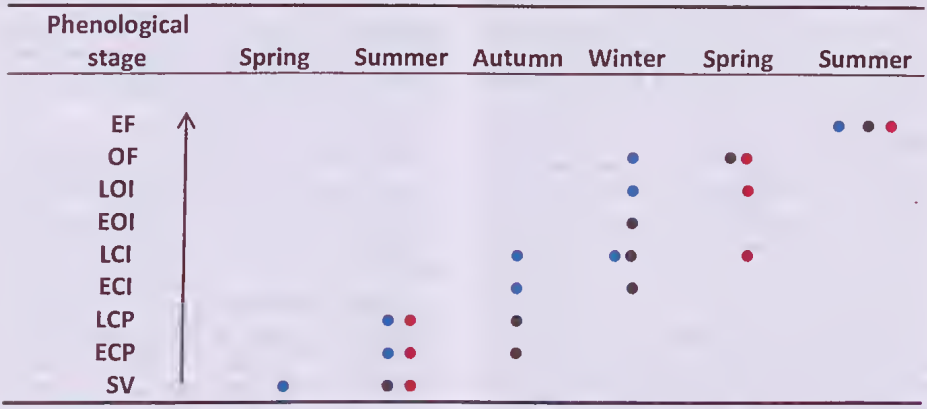

Fig. 3. Sporophyte developmental sequences for *Rhaphidorrhynchium amoenum* (blue), *Wijkia extenuata* (black) and *Rhynchostegium tenuifolium* (red) showing peaks of occurrence for phenological stages. Data was pooled from forest regenerating following logging (i.e. at 10, 15, 20, 25 and 30 years-since-harvest) and from a 63 year old forest. Arrow indicates increasing level of maturity. SV=Swollen venter, ECP=Early calyptra in perichaetium, LCP=Late calyptra in perichaetium, ECI=Early calyptra intact, LCI=Late calyptra intact, EOI=Early operculum intact, LOI=Late operculum intact, OF=Operculum fallen, EF=Empty and fresh.

species may be very different and require further investigation. Other studies, such as those of Cronberg *et al.* (2003), found logging did affect sexual reproduction. They examined the effects of forest age post-logging in *Plagiomnium affine* and found that female bias occurred at the ramet level although balanced sex ratios occurred at the genet level. They also found forest age positively correlated with sporophyte numbers and negatively correlated to the percentage of non-expressed shoots. Obviously, the results for one species cannot necessarily be used to predict what happens to another species, although in management this frequently occurs.

It was not surprising that logging did not affect sexual reproduction, as many mosses show strong seasonality in terms of reproductive development and fertilisation events. This suggests temperature, moisture levels and daylength beyond the range of variation caused by logging would be triggers for the onset of phenological events. This, in turn, suggests the seasonal cycle is genetically controlled (Mishler and Oliver 1991; Sinclair 1999). Seasonality of the phenological cycle has been demonstrated for *Atrichum androgynum* (Biggs and Gibson 2006), *Atrichum undulatum*, *Bryum argenteum* (Miles *et al.* 1989), *Atrichum angustatum* (Zehr 1979), *Mnium hornum* (Greene 1967), *Pleurozium schreberi* (Longton and Greene 1969), *Dicranoloma billarderii*, *D. platycaulon* and *D. menziesii* (Milne 2001). In other species, the sporophytic cycle is seasonal although the gametangial cycle is not, e.g. *Grimmia pulvinata* and *Tortula muralis* (Miles *et al.* 1989). Other species, e.g. *Funaria hygrometrica*, show no seasonality in development of their phenostages but can produce gametangia and sporophytes throughout the year (Longton 1976).

Development of sporophytes in *Rhaphidorrhynchium amoenum*, *W. extenuata* and *Rhynchostegium tenuifolium* extended over a 12 to 14 month period. This was not unusual. Some species complete development in a few months while others take years. *Dicranoloma platycaulon* and *D. billarderii* take 18 to 24 months (Milne 2001), *Atrichum rhystophyllum*, *Pogonatum inflexum* (Imura 1994) and *Entodon cladorrhizans* (Stark 1985) take nine months, and *F. hygrometrica* can take as little as two months (pers. obs. M Gibson).

Archegonia often undergo rapid development while antheridial development often requires more time (Imura 1994; Miles *et al.* 1989; Milne 2001). In these situations, maturation of both the male and female gametangia often occur at the same time and facilitates more successful fertilisation, particularly in dioicous spe-

cies (Longton and Greene 1967, 1969; Imura and Iwatsuki 1989). This study examined two dioicous, *Rosulabryum billarderii* and *W. extenuata*, and two monoicous species, *Rhaphidorrhynchium amoenum* and *Rhynchostegium tenuifolium*. The length of time required for development of the gametangia of the four species examined in this study requires clarification.

Sixty per cent of bryophytes are considered dioicous (Wyatt and Anderson 1984). Thus it is understandable that most published studies concerning sex ratios were on dioicous species. Dioicous species are known for their female biased sex ratios and high levels of non-expressed stems; however, while *Rosulabryum billarderii* continued the trend with a higher level of non-expressed stems than fertile stems, *W. extenuata* had a greater number of stems showing sex expression. If stress had an effect on the number of female and male stems produced, it would be expected to be seen in species of the younger, more open forest, where the moss is more exposed and subjected to less humidity and shade than in the older forests of 30 and 63 years-since-harvest. This, however, was not the case; neither species showed a significant difference in sex ratio with forest age in terms of either stem number or the number of inflorescences.

The monoicous mosses, *Rhaphidorrhynchium amoenum* and *Rhynchostegium tenuifolium*, were expected to have high numbers of sporophytes due to the ability of many monoicous species to self-fertilise. This was found to occur in Japan where investigation into 81 mosses, 61 dioicous and 20 monoicous, found the monoicous mosses had much higher rates of fertilisation than the dioicous species (Une *et al.* 1983 as cited in Stark 2002). In this study, whilst *Rhaphidorrhynchium amoenum* followed suit with sporophytes on 98% of fertile stems, *Rhynchostegium tenuifolium* had sporophytes on only 21% of fertile stems. Kimmerer (1991) found that in the monoicous species *Tetraphis pellucida* sex expression increased as shoot density increased. This phenomenon was not examined in this study. Kimmerer also found that as shoot density increased, the number of males increased and grew to outnumber the females. Both species showed a tendency towards a male bias although this was not statistically significant. *Rhynchostegium tenuifolium* demonstrated a male bias in terms of both perigonia and antheridia. *Rhaphidorrhynchium amoenum* had a greater number of antheridia than archegonia, which offset the greater number of perichaetia than perigonia.

Rhynchostegium tenuifolium has both male and female inflorescences on the same stem but on separate branches. This may contribute to the lower sporophyte production in *Rhynchostegium tenuifolium* compared to *Rhaphidorrhynchium amoenum*, which has both male and female inflorescences on the same stem or branch. Distance for sperm to travel would, therefore, be smaller in *Rhaphidorrhynchium amoenum*, thus fertilisation is likely to occur more often.

Concluding remarks

No statistically significant differences occurred in the number of unisexual or bisexual stems, or the number of inflorescences, gametangia or sporophytes across the chronosequence for any of the four species. Nor was there any obvious difference in timing of the reproductive phenostages for either sporophytes or gametophytes. This suggests that time post-harvest did not have a deleterious effect on the sex expression of mosses investigated. Other studies, however, have found effects of harvesting on bryophyte phenology and reproduction, or environmental effects that could be due to the changed conditions of forests regenerating subsequent to harvest. It is not possible, therefore, to use one species as a surrogate to predict what might occur in other species, as is often done in management. More studies on reproduction for Australian bryophyte species are recommended to provide for more informed management of bryophytes both within forests that are harvested and within our protected forests. Data used in this study were seasonal, and monthly sampling is recommended as it might better indicate any post-harvesting effects; however, this is very time-consuming.

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Glossary

(after Meagher and Fuhrer 2003)

acrocarpous Having sporophytes terminal on stems or branches. Old sporophytes can seem to be lateral as the branches resume growth in the subsequent growing season. The majority of acrocarpous mosses are erect.

antheridium (pl. antheridia) The male sex organ containing motile male gametes.

antherozooid Motile male gamete produced in the antheridium.

archegonium (pl. archegonia) The female sex organ containing the female gamete (ovum).

calyptra In mosses, a thin membrane protecting the developing sporophyte and forming a hood over the sporangium (structure containing spores). It is shed at maturity.

dioicous Having the antheridia and archegonia on different plants.

inflorescence Cluster of sex organs and the specialised leaves that surround them.

monoicous Having male and female sex organs on the same plant.

operculum The cap or lid covering the mouth of the capsule, which detaches at maturity to allow dispersal of the spores.

perichaetium (pl. perichaetia) Female inflorescence, comprised of specialised leaves surrounding the archegonia.

perigonium (pl. perigonia) Male inflorescence, comprised of specialised leaves surrounding the antheridia.

pleurocarpous Having the sporophytes arising from specialised side branches, so that the habit or form of the plant tends to be creeping or pendent.

phenostage Developmental stage that can be defined by a start and end point.

venter Swollen part of the archegonium, containing the egg.

Archegonia, each with a swollen venter at the base containing an ovum. Photo by Maria Gibson.

The earliest known camera trapping in Australia: a record from Victoria

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Abstract
The use of automated cameras has become a favoured tool in fauna surveys because they are non-intrusive and a cheaper alternative to other trapping methods. But the use of camera traps is not new. This paper discusses some examples of the earliest use of camera trapping. (*The Victorian Naturalist* 132 (6) 2015, 171-176)

Keywords: cameras, fauna survey techniques

Introduction

Over recent years the use of automated cameras to detect wildlife has become an important tool for researchers in Australia and worldwide. The last 20 years, in particular, have seen a marked improvement in the reliability, portability and technological advancement of automated cameras. Indeed, the use of the 'camera trap' has grown exponentially amongst researchers in more recent times (Rowcliffe and Carbone 2008). They have now become a favoured tool for fauna surveys because they are mostly non-intrusive and a cheaper alternative to the many other techniques, such as trapping, hair snaring and interpreting scats and prints. As long as the practitioner is skilled, modern camera traps are relatively easy to use. However, this has not always been the case; one hundred years ago automated cameras were considerably more primitive and were usually hand built.

Pioneers of automated cameras

The historical use of automated cameras as a tool for the study of wildlife goes back some 125 years to the man considered the greatest pioneer of their use: an American, George Shiras III (Shiras 1906, 1913). Shiras used trip wires in order for his subjects to activate the camera. Today, most cameras use infrared detection technology in order to capture images. Shiras used complicated flash systems, external to the camera (Fig. 1), involving the use of magnesium to cause a bright flash, in order to illuminate his night shots (Fig. 2). Today, an array of infrared lights, within the camera, usually achieves illumination. As occurs today, however, Shiras used food lures to attract animals to the camera.

Another early pioneer of the technology, and perhaps the first to use cameras as a scientific tool, was Frank Chapman (Chapman 1927). He used Shiras's camera equipment to take photos of big cats in Panama, to see which species had left footprints that he could not identify. The camera technology was successful in achieving this, as he photographed Ocelots *Leopardus pardalis* and Cougars *Puma concolor* and was able to match their footprints.

Use of automated cameras in Australia

The historical use of camera traps in Australia is more recent than the images of Shiras and Chapman. They have been used, however, with varying levels of success, and across a wide spectrum of studies for fauna research in Australia since at least 1936.

Previously, it was thought that the earliest use of a camera trap in Australia (and indeed the southern hemisphere) was in Tasmania in January 1950 (Meek *et al.* 2015). An automated camera was used as a tool in the fruitless search for the Tasmanian Tiger *Thylacinus cynocephalus*. It was reported in the *Hobart Mercury* newspaper in February 1950 that:

> News of the extreme rarity of the Tasmanian "tiger" evidently did not impress at least one Victorian naturalist who arrived in Tasmania about a month ago equipped with camera and patent trip-lighting apparatus. Inspired by a large amount of optimism he set out to find and photograph one of the animals in its own environment.
>
> At least he had heard that it was not a common animal and therefore considered it should be photographed in the wild state before its extinction made such a thing impossible.

Fig 1. An early automated flash for a camera trap used by George Shiras (*National Geographic*, circa 1910).

Fig 2. An early automated camera image from George Shiras circa 1910. The Racoon *Procyon lotor* in the image has triggered trip wires which activated the flash and the camera. The powerful magnesium flashlight can be clearly seen.

> He spent some time at Adams-field, and also at Cockle Creek, looking for game pads worn sufficiently to justify setting his camera and flash equipment in concealment beside the track, with a trip-string placed in such a fashion that if a "tiger," or any other animal, in fact, passed that way, it would take its own picture.
> The cause was worthy, but the result, of course, quite negative. No "tiger" showed itself; but he did see a good deal of the real Tasmanian bush and enjoyed the experience. And, while asking me not to divulge his name as "it might make him appear silly," he left last week with the resolve to return for another few weeks in the Autumn, to work either at Port Davey or the Arthur River, where he believed a "tiger" might be found.

It appears that no 'tiger' was found on subsequent trips either.

Another, not so anonymous, Victorian sought to photograph the local wildlife in Victoria in 1936, some 14 years prior to the Tasmanian trip (Littlejohns 1939). It was reported in *Wild Life* in 1939 that Ray T Littlejohns (famed for his work on the Superb Lyrebird *Menura novaehollandiae* and Mistletoebird *Dicaeum hirundinaceum*, and a president of the Royal Australasian Ornithologists Union) had been experimenting with the use of an automated camera with an 'open flash-lamp' in order to take pictures of the Yellow-rumped Thornbill *Acanthiza chrysorrhoa* in its nest. He hoped to determine why it:

> builds an open nest or sleep-out attached to the cosy closed-in room, which contains the eggs (Littlejohns 1939: 9).

He then went on to describe how the camera and flashlight apparatus would require much space with its 'masses of cords and springs, its levers and its clockwork power-plant' (Littlejohns 1939: 9). He did indeed produce three photographs of the thornbill's open top nest, which unfortunately proved to be empty in each image. Later studies demonstrated that it is, in fact, a dummy nest designed to fool predators, thereby always remaining empty (Galligan and Kleindorfer 2008).

This account appears to be the first documented evidence of a scientific study by means of a 'camera trap' in Australia. It occurred during or just prior to 1936. Though no specific date was given for the thornbill trial, it acted as a precursor for a study undertaken in November 1936, to find the elusive 'native cat' (or Quoll, *Dasyurus* spp.) which was otherwise 'almost extinct in most parts of Victoria' but 'fairly numerous in the stony country near Lake Corangmite' (Littlejohns 1939: 10). This early search for the Spot-tailed Quoll involved firstly laying out food in likely areas in order to get the animal 'accustomed to visiting the spot' that was chosen to place the camera (Littlejohns 1939: 10). This process of familiarising animals to trap sites is now known amongst trappers as 'free-feeding'. Littlejohns (1939: 10) then described how a 'small metal plate was fastened to the ground and served as a switch for each apparatus, and the cameras were focused on the switches before nightfall'. He used two cameras over several nights, one of which failed to operate because it was faulty. The remaining camera, after several misfires and events in which the bait (consisting of rabbits) was removed without the cameras being activated, took three shots. The photographs from that camera were developed in Melbourne the next day and apparently consisted of several blurred images of quolls and a good image of a local farm dog eating the bait!

Littlejohns also used his cameras and flashlights in attempts to get more 'glamorous' images of native animals undertaking their normal behaviour in the wild. This was in contrast to his previous efforts in using his cameras for more scientific studies. He visited a waterhole near Bendigo where he placed two cameras which were 'set carefully with switches connected to threads stretched at the water's edge' (Littlejohns 1939:16). The intended targets were wallabies drinking at the waterhole. After much experimentation with placing the camera at just the right location, he was rewarded with some images of the wallabies, one of which was published (Littlejohns 1939). He then described the night at the waterhole as 'one of the most attractive adventures in the experience of a flashlight hunter' (Littlejohns 1939: 16).
Littlejohns describes these early camera traps as 'animal self-portraiture' (1939: 10) (Fig. 3). In the early attempts, the switches operating the flash and the camera were placed on the ground, but they were triggered 'consistently' by small

animals such as the 'Allied Rat' (or Bush Rat *Rattus fuscipes*). At a later stage, the switches were connected to a black thread stretched at 'such a height above the ground that the possums and the rats would pass beneath' (Littlejohns 1939: 10). However, he described how twigs dislodged by high winds frequently operated the switch. Littlejohns also describes how the 'Allied Rats' would be too fast once photographed and appeared as a 'blurred streak' on the negatives. He resorted to many 'ruses' and many 'gadgets' that were devised to overcome the problem of the 'momentary jump' of the subject, but the rat had beaten them all (1939: 10).

It was at this point that Littlejohns (1939) first used the term 'trap' when describing the trigger mechanisms connected to the flashlight, which in turn triggered the camera. This was not the first time that this term was used, however, as Frank Chapman used it in a feature article entitled 'Who Treads our Trails' in the September 1927 edition of *National Geographic* (Chapman 1927). 'Camera trapping' is the term that is now widely used amongst researchers today.

Littlejohns was not the only photographer experimenting with automated camera traps around this time. In January 1940, AF D'ombrain wrote an article in *Wild Life* (D'ombrain 1940) in which he discusses the technology of the time in more detail. The problems of moisture proofing, camouflage and power supplies were discussed, still relevant topics for researchers using camera traps today. One large difference, however, is that D'ombrain used a pair of 'powder charges' set up in just the right place to obviate shadows (Fig. 4). He described how the set-up of his devices required 'extreme care and thoroughness, all leads tested with an ammeter, shutter speed set, slide drawn and wires connected' (D'ombrain 1940: 15). It must have been a complex system, simply to take one photograph! Today, a camera trap can be set relatively quickly and multiple images can be taken over an extended period of time.

Into the Future

It may have been the Americans who pioneered the use of camera traps, and images they published in *National Geographic* in 1906 and 1913 are likely to have influenced other photographers such as Ray T Littlejohns, AF D'ombrain and the anonymous Victorian wildlife photographer. Modern camera traps have improved

Fig 3. An image circa 1936 showing a 'Silver-grey Possum' *Trichosurus vulpecula* caught on a camera trap by Ray T Littlejohns using honey as a lure. He included a clock in this image to record the time the photograph was taken. The image outside the white box was masked to provide the image only of the possum for publication.

markedly since the 1930s. Gone are the days of developing and building your own equipment. Modern units tend to be purpose built and available from retailers. They can operate in low light conditions, have electronic triggers rather than physical trip switches and they are, of course, digital. Many can also take video footage and even send images to modern handheld devices such as smartphones and tablets.

In Australia, modern camera traps have been used in recent years for a wide range of wildlife studies, including monitoring the cryptic and endangered Spot-tailed Quoll (Nelson *et al.* 2014), measuring scavenging activity on animal carcasses (Forsyth *et al.* 2014), assessing the impacts of control programs for pest animals (Gormley *et al.* 2011) and even monitoring wildlife responses to fire (Robley *et al.* 2013).

It will be interesting to see how camera trapping develops into the future, given the advances in the technology over the previous one hundred years. Perhaps in another hundred years we will have camera traps that recognise animal species, alert the researcher to the presence of endangered species, or even make estimates of abundance and other wildlife population parameters.

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Fig 4. An image of AF D'ombrain's camera set up with one flashlight charge on each side of the camera in order to remove deep shadows. Taken from *Wild Life*, January 1940.

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Ramaria abietina: A rare Coral Fungus

Introduction

It is quite common for rare or undescribed species of fungi to be found on forays or by searching. In this case, the discovery was unusual—an email with photograph was sent to Pat and Ed Grey via a friends group. The find was made by Marc Campobasso and, from Marc's photograph, the fungus was identified as the Green-staining Coral *Ramaria abietina* (Figs 1 and 2).

This species is apparently rarely found in Australia, although it is known from the northern hemisphere. The find aroused the interest of Dr Tom May, Dr Teresa Lebel (both from RBG Victorai) and Tony Young in Queensland. The Atlas of Living Australia (2015) shows only fourcollections – one from New South Wales (Bradley's Head, Sydney) and two from South Australia (from the same locality, Meningie near The Coorong) and one very recently uploaded, undated observation from Point Addis near Anglesea in Victoria. Young (2014) has an entry for the species in his online treatment of the Australian species of *Ramaria*, mentioning additional collections from Lane Cove, Sydney, and noting that there are few descriptive details available on Australian collections.

An arrangement was made with Marc Campobasso to meet at the site in order to make a collection from which a written description could be prepared, prior to lodging at the National Herbarium of Victoria. The site is close to the Merri Creek Bike Trail, Coburg (near Melbourne) in a revegetated area.

Description of fruit-body

Macroscopic features

Fruit-body: Small, height to 35 mm, width to 25 mm; coralloid, branched, branching three times; axils u-shaped; yellowish, staining green.
Branches: Upright, cylindrical, slender; yellowish becoming green with age or bruising.
Branch tips: Bluntly pointed; yellowish becoming dark green.
Stem: Short, length 10–15 mm, diameter 1–2 mm; white at base, greening towards first branching; usually buried below the surface of substrate and covered in downy white mycelium. At the stem base is a white mycelial mat with white rhizomorphs arising from the mat and extending into the substrate.
Spore print: Yellow.

Microscopic features

Spores: Pip-shaped to narrowly ellipsoidal; prominent, curved hilar appendage; finely roughened; 6.0–8.5 × 3.5–4.0(-5.0) µm (n=20), mean 7.04 × 3.93 µm, Q (length to width ratio)1.66–2.10.

Habit, substrate and habitat

Habit: Clustered groups, often in an arc around tree base.
Substrate: Ground amongst litter (mainly Lightwood *Acacia implexa* leaves at this site).
Habitat: In a revegetated metropolitan park with a coppice of Lightwoods, a solitary Swamp Gum *Eucalyptus ovata* and an understorey of Saltbush *Einadia trigonos* ssp. *trigonos*.

Fig. 1. *Ramaria abietina,* Merri Creek Trail. Photo by Marc Campobasso.

Fig. 2. *Ramaria abietina*, Merri Creek Trail. Photo by Ed Grey.

Etymology
Ramaria: possessing branches; *abietina*, from the latin abies meaning fir tree. In the northern hemisphere, this fungus is often found with Spruce.

Collection examined
MEL 2392603, 2 July 2015. Merri Creek Trail, near Fyffe St, Coburg. Collectors Grey EJ & PM, Campobasso M.

Discussion
The spore dimensions of the recent collection from Victoria match those of Australian material provided by Young (2014): spores 5.8–7.9 (–8.6) × (2.5–)3.0–4.3(- 4.7) µm, mean Q 1.95, narrowly ellipsoid to lacrymiform, golden-yellow in mass under the microscope, hilar appendix prominent and curved, profile echinulate, ornamented with randomly scattered, acutely tipped spines 0.3–0.8(1.0) µm. Note that the spines were not resolvable with our microscope.

The distinguishing features of this fungus are its small size, the green staining which develops on bruising or with age, and the white mycelial mat with the associated white rhizomorphs. The small-size of the fruit-body and its yellow-green colour means that this coral could easily be overlooked or mistaken for a moss. While describing Northern Hemisphere material, Arora (1986), Breitenbach and Kranzlin (1986) and Laessoe (2013) state that the habitat of this fungus is among conifers (more rarely hardwoods). According to Young (2014) Australian material has been found in 'fallen leaf mould' (first SA collection), on a 'wood-heap' (second SA collection), on mossy soil amongst litter in *Melaleuca lanceolata* woodland (Anglesea, Vic.), garden on soil composted with grass clippings and leaf litter (first Lane Cove collection). Young (2014) suggest 'dry eucalypt woodland on sandstone based soils' as the habitat for the Bradleys Head collection. The find in Melbourne extends both the range and habitat for this distinctive species. It is interesting that all known records are from coastal or near-coastal sites.

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One Hundred Years Ago

THE FORESTS OF VICTORIA
PART II.*
by A. D. Hardy, F.L.S., Forests Department.
From a paper read before the Field Naturalists' Club of Victoria, 8th November 1915
VII.—REFORESTATION

Given rest from fires, the native hardwood forests perpetuate and even after fires restore themselves. As matured growths are removed, light penetrates more easily, and in an almost incredibly short space of time several straight saplings shoot up to fill the gap. The old trees, if left to decay, make breeding grounds for boring and other noxious insects and fungi ; when falling destroy other growths ; and when down litter the ground with *débris* which prevents seedling growth for many years, and makes fuel for ground fires. Against these defects there is, of course, the benefit derived b y the soil from the mouldering tree in course of many years, and the advantages gained in conservation of stream flow by the retarding effect of the ground litter on the get-away of rains.

From *The Victorian Naturalist* **XXXII**, p. 117, December 9, 1915

Jean Galbraith: Writer in a Valley

by Meredith Fletcher

Publisher: *Monash University Publishing, Clayton, Victoria, 2014. xxii, 292 pages, paperback, black and white and colour illustrations. ISBN 9781922235398. RRP $39.95*

Jean Galbraith (1906-99) spent most of her long life in Victoria's Latrobe Valley. She lived in the family home 'Dunedin' in Tyers, near Traralgon, with her parents and brothers, and later looked after a succession of ailing relatives there. From 'Dunedin', Jean observed the plants and creatures of the valley's changing landscapes and, long before it was considered practicable or desirable, began growing native plants in the garden. Guided by curiosity, care and, increasingly, concern, she recorded her observations in and beyond her beloved garden.

Completing her formal education at the state primary school in the small dairy community of Tyers, Jean was fascinated by the local flora and wanted to learn more. Baron Ferdinand von Mueller's *Key* was still the authoritative text on Victoria's flora, and nature articles could be found in Melbourne newspapers and, of course, *The Victorian Naturalist* (*TVN*) of the Field Naturalists' Club of Victoria (FNCV). And there was also the Club's very popular wildflower show each spring.

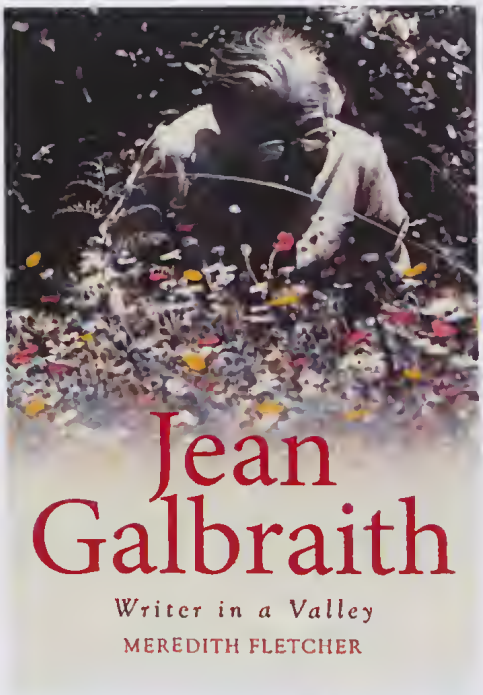
In October 1922, 16-year-old Jean caught the train at Traralgon to attend the FNCV's wildflower show in the Melbourne Town Hall. Entranced by the floral beauty and diversity, Jean asked the chief organiser, HB Williamson, many questions. The following year, she assisted Williamson at the classifying table and, at his suggestion, joined the Club. In 1925 she provided an impressive display of wildflowers from the vicinity of Traralgon.

For Jean, the FNCV opened a door to the world of botany. She was already familiar with the writings of several members: Charles Barrett, author, *Herald* nature writer and editor of *TVN*, Edward Pescott, author of *The Native Flowers of Victoria*; and Edith Coleman, whose native orchid articles were beginning to appear in *TVN*. Jean's weekly correspondence with Williamson benefited both. Williamson answered her questions and identified her specimens, which—with her detailed field notes—enriched his substantial herbarium and knowledge of Victoria's flora.

In the mid-1920s, Jean began contributing to *TVN* and the new *Garden Lover* (later *The Australian Garden Lover*). Using the pseudonym 'Correa', Jean introduced *Garden Lover* readers to indigenous plants in her series 'Australian Native Flowers'. Barrett included her field notes and articles in *TVN* and introduced her to Donald Macdonald, *Argus* nature writer, whose columns she had long enjoyed reading. As Meredith Fletcher explains: 'Through her correspondence with H.B. Williamson she became a botanist; … Charles Barrett guided her reading and writing; Donald Macdonald encouraged her inspiration from nature and her nature writing' (p. 103).

Jean's *Garden Lover* articles gently carried conservation messages and led readers out into the bush. When the *Wild Flowers and Native Plants Protection Act* was passed in 1930, Jean explained the new legislation in *The Garden Lover* and provided a display of protected plants (from private land) at the FNCV's1931 Wild Nature Show. She later converted her *Garden Lover* articles into chapters for her 1939 book, *Garden in a Valley*.

A decade later, Winifred Waddell founded the FNCV's Native Plants Preservation Group (later Society), dedicated to establishing wildflower sanctuaries. Aware of the need to overcome the widespread ignorance about Victoria's native flora, she organised funding and a publisher, and asked Jean to write a popular but accurate field guide. Realising that such a project required access to the collections and library of Melbourne's National Herbarium of Victoria, Jean asked JH (Jim) Willis, Herbarium botanist (and FNCV member) for his help. Willis provided taxonomic and other botanical advice, colorgravure and wrote the preface to *Wildflowers of Victoria* (1950, 1955), which de-



scribed nearly half of Victoria's more than 2000 known species. Fletcher discusses the publication problems that Jean endured in preparing *Wildflowers of Victoria*, its huge popularity with FNCV members, and the FNCV's involvement in the publication of a third edition by Longmans in 1967. While preparing revisions, Jean was permitted to stay overnight in the Herbarium, sleeping on the Baron's couch.

Baptised Christadelphian, Jean deplored the destruction of God-given beauty. Coal mining and forest clear-felling are not attractive processes. As she watched the conversion of nearby riverflats and forests into industrial landscapes, her conservation voice intensified. As the Gippsland representative of the Native Plants Preservation Society, she negotiated the establishment of wildflower sanctuaries and bush reserves and, in 1960, was a founding member of the Latrobe Valley Field Naturalists' Club (LVFNC), which sought to study and save precious remnants of the indigenous vegetation. LVFNC 's assistance facilitated her preparation of some of her more than 110 *TVN* contributions.

With travel help from LVFNC members and more distant friends, Jean, still without a car, described three quarters of the about 4000 known species indigenous to Australia's eastern temperate region in *A Field Guide to the Wild Flowers of South-East Australia* (Collins 1977).

In his review in *TVN*, Willis couldn't 'speak too highly of this excellent, very readable and easily understandable volume' (p. 225).

Jean was a remarkable writer. She wrote engagingly for children as well as adults. Before photographs commonly illustrated articles and books, she used beautiful word pictures to describe her subjects.

Elected an honorary life member of the FNCV in 1959, Jean Galbraith was awarded the Australian Natural History Medallion in 1970 for promoting interest in natural history and conservation in the general community and 'a greater awareness of our natural heritage' (p. 217).

Towards the end of her life, Jean Galbraith was honoured botanically. Three rare and threatened Victorian species bear her name - *Boronia galbraithiae* Galbraith's Boronia, *Dampiera galbraithiana* Licola Dampiera, and *Prostanthera galbraithiae* Wellington Mint-bush. She is also commemorated by a reserve at Tyers - the Jean Galbraith Flora Reserve. Colour photos portray two of the several endemic Victorian plants named after her—*Boronia galbraithiae* and *Prostanthera galbraithiae*.

Read this fascinating biography to learn how this gentle, modest, generous woman managed to develop her botanical interests and writing projects around numerous domestic duties as aunt, niece, daughter and carer, but not wife or mother. Discover how, from the home of her pioneer settler family, she became a pioneer nature writer and conservationist, as well as a respected botanist.

Meredith's book was the worthy winner of the major prize in the 2015 Victorian Community History Awards.

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Louisa Atkinson's Nature Notes

Selection and commentary
by Penny Olsen

Publisher: *National Library of Australia, in association with the State Library of New South Wales, 2015. 108 pages, paperback. ISBN 9780642278609. RRP $34.99*

This new National Library of Australia publication features Louisa Atkinson's paintings and drawings of Australian plants and animals, including birds, together with short extracts from her nature writings. The book also includes a short essay about her life and early death at 38. Louisa's mother trained in England with the artist John Glover and possibly inspired her daughter's talents in the same area.

Louisa was born in 1834 in the Berrima district of NSW. She became a writer, journalist, artist and naturalist and wrote articles for the three Sydney newspapers. She wrote of bushfires, the lives of indigenous people and the value of herbs. She belonged to the Horticulture Society and in her short life also found the time to write six novels. She became a well-loved member of the community, helping the illiterate, visiting the old and sick and setting up the district's first Sunday school.

At the age of 19, she began contributing nature articles for the Sydney newspapers. She created many artworks of flora and fauna around her home in the Blue Mountains, most of which were unpublished in her lifetime. Her mother and her siblings had troubled lives, which improved after they sought the tranquillity of the beautiful Blue Mountains. Louisa married James Snowden Calvert and the newlyweds had a shared interest in natural history. Those readers who have seen Edith Holden's book *The Country Diary of an Edwardian Lady* will see the similarities to the way this book has been written and illustrated.

One can only wonder what more Louisa would have achieved had she lived longer. She was a woman before her time, when few women wrote in such detail about natural history. Perhaps the fact that Louisa never attended school due to her ill health provided her intelligent and enquiring mind with the time to pursue her passion for the natural world. Some of her work is in the Mitchell Library, State Library of New South Wales and in the National Library of Australia. I would recommend that her work be sought out when visiting Sydney or Canberra. I know I will be standing in awe at what Louisa Atkinson accomplished during her short life next time I visit those cities.

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Australian High Country Raptors

by Jerry Olsen

Publisher: *CSIRO Publishing, Collingwood, Victoria, 2014. 336 pages, Paperback. ISBN 9780643109162. RRP $69.95*

This is a very personal account of Australian raptors (including a little on owls) and the author's experiences with them. It gives some illuminating comparisons with raptors elsewhere in the world and attempts to answer intriguing questions about them. The title may conjure images of remote rugged mountains, providing refuge for soaring eagles as they do elsewhere. Jerry moves quickly to dispel this view: in Australia we are lucky to have habitat for raptors over much of the country, and none of them really favour the high mountains. As with his previous book on high-country owls, and Harry Frith's classic *Birds of the High Country*, he defines high country as >600 m in south-eastern Australia. Jerry focuses primarily on the partly cleared gentle hill landscapes near Canberra where he has done most of his work on breeding raptors.

Jerry is passionate about raptors and this book is enriched with anecdotes from his work and travels in Canada, Mexico, Chile, Spain, etc. and his academic upbringing in USA. He poses challenging questions about why so few Australian raptors (or other birds) nest on cliffs (answer: eucalypts make great nest sites!); why raptors rarely nest above 1200 m (with information on the limits of tree growth) and debunks the myth that Wedge-tailed or Little Eagles have become dependent on rabbits for food. For the biologist, he gives useful summaries of his work on breeding raptors and their diets and ecology and breeding success. Where possible, he relates success to available data on prey abundance (e.g. the Canberra bird surveys by COG/ Phillip Veerman, and Rod Kavanagh's work on arboreal mammals as prey of Powerful Owls). Jerry gives an excellent account of Derek Ratcliffe's pioneering exposure of the pesticide problem for Peregrine Falcons in UK (with worldwide implications). He gives due credit to the work of A Starker Leopold and Aldo Wolfe as pioneers of raptor ecology in the ACT, and summaries of other relevant raptor studies. He briefly mentions Rohan Bilney's fascinating work on sub-fossil cave deposits, indicating a massive recent decline in terrestrial prey for forest owls, but then claims that diurnal raptors have had even more of a prey shift because they now take a much higher proportion of introduced species. There are chapters on anatomy, physiology, ethics and the care of injured raptors. For the general reader, there are lively accounts of Jerry's adventures in Australia and overseas, and his encounters with raptors, people, naked bathers and much more.

An interesting chapter deals with sexual dimorphism: why female raptors are often larger than males, or the other way round in our

Ninox owls (and many non-raptors). The story is complex and evolving, but Jerry makes some key points. Raptors are special because their talons and hooked bills allow only single prey items to be carried (in contrast to thrushes with multiple worms or puffins with multiple fish): this limits the use raptors can make of abundant small prey such as insects. Vertebrate animals actively hide from predators, and hunting them involves risks (e.g. collisions with trees or vehicles). Hence it is useful for the main provider (usually male) to be small and agile. *Ninox* owls are different because the smaller species often take invertebrates (albeit singly) and the larger species may store prey species in their talons until the next day.

There are some surprising omissions. Jerry emphasises the inability of falcons to build their own nest structures, but does not mention the recent molecular work, that aligns falcons taxonomically with parrots not hawks. Square-tailed Kites get no mention, despite being one of the few raptor species that feed mainly in forests and dense woodlands (albeit mainly in the lowlands, as for other raptors), and sometimes nest >600 m in this region where forests are a key habitat. The chapter on conservation is brief and excessively focused on Canberra. It mentions umbrella species (with a single overseas reference and a naïve comment about its value), but not our successful use of the concept in Victoria to protect 350000 ha of forest specially selected for forest owls and the ecosystems on which they depend.

Nevertheless, this book serves a useful purpose and will be enjoyed for its questioning and challenging approach, valuable information summaries, the way it links information from Australia and overseas, and Jerry's evident humour and passion for the subject.

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Camera Trapping: Wildlife Management and Research

Principal Editors: Paul Meek and Peter Flemming

Publisher: *CSIRO Publishing, Collingwood, Victoria and Australian Wildlife Management Society and the Royal Zoological Society of NSW, 2014. 367 pages, paperback. ISBN 9781486300396. RRP $89.95*

This large volume is essentially a collection of 32 scientific papers written from presentations delivered at a camera trapping symposium that took place in Sydney in 2012. Camera trapping is a burgeoning technique replacing many other traditional wildlife survey methods, hence the need for the colloquium. This book is organised into five parts, each covering different aspects of camera trapping as a tool for the wildlife researcher.

If anyone or any organisation uses or intends to use camera traps as a survey tool, this is a useful volume as it covers all the information needed to carry out a successful camera trapping survey. That said, the book is not laid out as a field manual, but rather as a reference into which a camera trapper may delve to ascertain hints, tricks and techniques that have been successfully, or indeed unsuccessfully, used by researchers from around Australia and beyond.

The book opens with a preface followed by an introduction from the principal editors in which the reasoning for holding the camera trapping symposium (the first of its kind) are explained. It describes how wildlife researchers and managers have been installing cameras frequently with no real forethought or strategy, in the hope of answering all their wildlife issues. Camera trapping is, of course, no panacea in understanding wildlife ecology and the editors

are keen to point this out. The complexities and constraints are brought to light within the introduction.

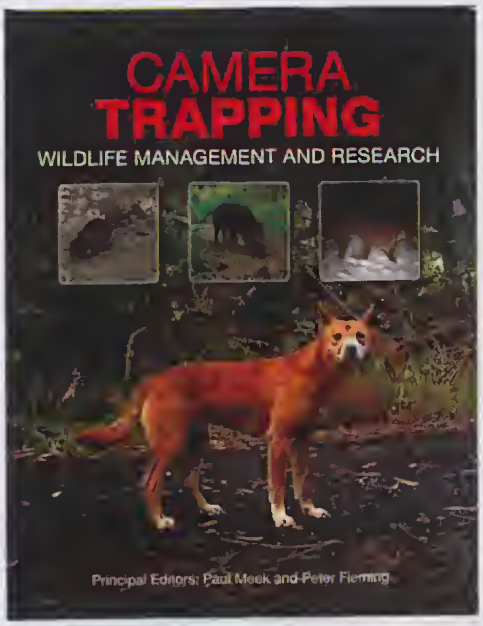
Part one consists of 10 papers presented on multiple topics concerning aspects of camera trapping under the guise of case studies. Whilst these are interesting, there is no real logical format from which to gain practical advice. The fact that this book is a collection of independent presentations is quickly made apparent as there is frequent repetition. However, if camera trappers are prepared to read these case studies, they will undoubtedly pick up some knowledge for using their traps. It is nice to see, and indeed interesting to read, that many of the case studies are from other regions around the world including Mongolia and Bhutan.

Part two deals with the technology used within camera trapping. It is a collection of seven papers and a very useful part of the book. It describes other researchers' camera trap installations, the snags they have hit along the way, how these were overcome and general insights into the best ways of using camera traps. This information is what many readers of this book will be hoping to find.

The middle of the book contains a collection of colour plates relating to some of the papers in the book. Whilst some of these images are nice to view, only a handful of them are genuinely useful as colour plates. Many would have been adequately presented alongside the text within the body of the relevant paper as other diagrams and plates are throughout the book.

Part three is probably the core of the book. It deals with techniques, protocols and comparisons in setting up your camera trap study. It defines realistic expectations of the type and quality of data that can be collected. Whilst every study may be slightly different, there is no point in re-inventing the wheel and this chapter provides the camera trap user with some useful knowledge in designing a meaningful study.

Part four deals with how to manage and analyse your data. Much of this will be of use only to those with multiple camera traps available to sample an area. This may be of more value to research and academic institutions with multiple data sets requiring analysis, than most community groups or casual naturalists. However, the final paper in this section, on privacy law in Australia, will be of assistance to all users!



The final part comprises a single paper written by all the editors involved in collating the book. This conclusion usefully attempts to sum up all the issues related to camera traps, as well as laying out a future in standardising techniques and forming a registry of camera trap research.

If you are considering undertaking a camera trap study, this book will provide a useful reference text. It is not however, a 'go to' manual, and will require some perusal before the best information can be gathered from it. There is some repetition in this book, but this is a product of it being a collection of presentations written up as papers. Overall, a very useful book.

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Thank you from the Editors

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